

Hydrology

Hydrology Committee Proposal No. 1
San Juan RIP Naturalized Flows
Recommendations For Addressing Problems
Fiscal Year 2002 Project Proposal

Background:

During September 2000, Hydrology Committee FY 2001 Proposal No. 1 was submitted to the Coordination Committee. This proposal outlined a process to reconfigure the hydrology model that was used to evaluate operating scenarios to determine if they meet the flow recommendations and to check, improve and/or replace data that were being used in the model. Small improvements were being made as the model was being used. However, because of several problems that existed with the model and the data used in the model, it was felt by the Hydrology Committee that a major overhaul was needed.

The Coordination Committee approved the proposal and agreed that San Juan River Basin Recovery Implementation Program funds could be used to work on the model. Work on the model was scheduled to start as soon as funding was approved. However, because of not knowing if funds were going to be available (problems at Western Area Power Administration), work on the model using program funds did not commence until January 2001. Some work was initiated using other funding sources.

Work is now proceeding on the overhaul of the model and on updating and correcting the data. However, because of the funding problems and not getting started on time, not all of the approved funds will be spent in FY 2001. \$363,419 will be needed in FY 2002 to complete the work on the model. Work will continue as outlined in the FY 2001 Proposal, however, on a different time schedule. Table 1 shows an estimate of what will be completed in FY 2001 and what work will be completed in FY 2002.

Area of study:

The Area of study/hydrology modeling area includes the whole San Juan River Basin to Lake Powell.

Objectives:

The objectives of the modeling work remains the same as proposed in the FY 2001 Proposal and includes improving confidence in the model through improved data consistency, better modeling methods, better coordination and input with stakeholders, and improved model documentation.

Method of Approach:

In the process of completing the work in FY 2001, several of the tasks as outlined in the FY 2001 proposal, have either been combined with other tasks or the tasks have been divided into

several smaller tasks. This was done in order to help members of the Hydrology Committee better understand what was being done.

The following task descriptions as outlined in the FY 2001 is provided for reference. A summary of the status of each task is provided at the end of each task description.

A. Analyze gage errors and correct gage record as required for reasonable water balance.

Relationship to naturalized flow study: Could be implemented in existing model as a naturalized flow correction. Required as a part of the naturalized flow study.

Need: Existing gage records show periods of channel losses between gages, particularly between Bluff and upstream gages, that exceed reasonable losses. The losses usually occur during snowmelt runoff when flows are high and are as much as 100,000 AF in a given month when adjusted for other gaged inflow and diversions between gages. These large losses result in an under-estimation of streamflow and a model-projected failure to meet flow recommendations during times that they would otherwise be met.

Impact on available water: These errors have a direct impact on available water. While the magnitude of the errors have not been precisely determined nor the impact of their correction modeled, it is anticipated that additional water to meet the various system demands or more flexibility in dam operation may be provided.

Approach: A down-river water balance will be computed utilizing Archuleta, Animas at Farmington, San Juan at Farmington, Shiprock, Four Corners and Bluff gages. To identify the errors, unexplained gains and losses would be computed for each reach by adding gaged inflow and subtracting phreatophyte losses and estimated depletions between gages. An assessment of change in groundwater storage will also be computed and included in the analysis. Corrections to the computed gain or loss will be applied to adjust flow at anomalous gages by comparing gain/loss in adjacent reaches and adjusting the gage in error to arrive at balanced gain/losses relative to reach conditions. Previously estimated phreatophyte losses and man-induced depletions will be utilized in completing the adjustments. A technical memorandum will be prepared (funded under the documentation task, but completed within the schedule for this task) and circulated for review and approval of the approach by the Hydrology Committee and USGS prior to implementation.

Responsible Party: Consultant

Status: Contract to complete this task has been awarded and task is scheduled to be completed by September 1, 2001.

B. Evaluate CDSS model and databases, methods and documentation, resolve differences with San Juan River Basin Models (SJRBMs) and data, and develop interface approach.

Relationship to naturalized flow study: Required as a part of the naturalized flow study. Not needed otherwise.

Need: CDSS and RiverWare presently do not have the same file structure, data needs or functionality. A careful review of the CDSS models, databases, and subsequent naturalized flow generation process is needed to develop the approach to interface the two modeling systems.

Approach: Reclamation will work with the state of Colorado or a designated consultant familiar with CDSS to resolve differences including depletion categories, modeling of off stream depletions, generation of synthesized data, nomenclature and configuration, and flow computation procedures and assumptions. Any functionality that would need adjustment in CDSS as recommended by the Hydrology Committee would also be identified. Once all issues are identified, a process for interfacing the two models would be developed, including methods of implementing CDSS functionality in RiverWare.

Responsible Parties: Reclamation and either the state of Colorado, a consultant familiar with CDSS or a combination.

Status: This task is approximately 77% complete. Interfacing of time-series data is complete. Node and support data interfacing are partially completed.

C. Develop data storage, analysis and retrieval system, including Data Management Interfaces (DMI's) between respective applications and databases.

Relationship to naturalized flow study: Required as a part of the naturalized flow study. Not needed otherwise.

Need: To provide seamless data sharing and analysis and to enhance model documentation, maintenance and upgrade functionality. interface tools (DMI's) will be developed.

Approach: This task addresses data handling only, whereas Task B is specific to modeling processes and interface approach. To the extent possible, data will be shared between databases using standard database exchange protocol, not directly between models. Text file formats will be consistent with existing data formats or as designed by the team. All CDSS computed data including depletions, synthesized flows, and naturalized flows will be populated in an appropriate Reclamation database. The population process will be automated to the extent possible, to improve the process of updating data. Data Management interfaces (DMI's) will be developed for each model to allow extraction and importation of the appropriate data from the respective databases.

Reclamation has existing GIS and time-series databases that run on various platforms. DMI's that communicate between databases and applications use Open Database Connectivity (ODBC) and Java Database Connectivity (JDBC) which are standard protocol for database communications. Existing databases or schemes would be enhanced and extended to support SJRBM. Data entry, data retrieval, and data integrity will be facilitated by use of databases and standard communication protocols.

Responsible Parties: Primarily Reclamation with some consultant time. Consultant must be familiar with CDSS and/or RiverWare.

Status: This task is approximately 77% complete. Database interfacing is mostly done but additional database development remains.

D. Correct 1970-1993 database to address concerns.

Relationship to naturalized flow study: Required as a part of the naturalized flow study. If naturalized flows are not recomputed according to the process outlined, then this task should go forward to correct known problems. The scope would change, however.

Need: The non-Colorado data in the CDSS database consists of the same values used in the present RiverWare model. There are some uncertainties concerning representation of values in the model, including reservoir evaporation, inconsistencies in non-agricultural depletions, concerns over crop mix and acreage and differences in estimates of consumptive use. These data elements need to be reviewed, updated and corrected to improve accuracy of naturalized flow estimates during this period.

Approach: Reclamation will work with the state of New Mexico to resolve differences in assumptions concerning New Mexico depletion issues, with review and approval by the Hydrology Committee before inclusion in the model. Reservoir net evaporation rates (evaporation less rainfall) for all reservoirs in the basin will be computed on a monthly basis for the period of record, rather than using average values as presently done. Arizona and Utah depletions will be reviewed, corrected and updated prior to inclusion in the database. All new data will be provided to Colorado for inclusion in the naturalized flow computation. The data will be provided as text files for inclusion through CDSS DMI's. All new information will be reviewed by the Hydrology Committee before final inclusion into the model.

Responsible Parties: Primarily Reclamation, with support from consultant familiar with the San Juan Basin, working with the states of New Mexico, Utah and Arizona.

Status: The task is approximated 20% completed. Reconfiguration is nearly completed but time series data development remains to be completed.

E. Extend data sets that do not exist to 1929.

Relationship to naturalized flow study: Required as a part of the naturalized flow study. Even if naturalized flows are not re-computed, analysis and verification of the nature of depletions prior to 1970 should be completed, although the analysis would be different.

Need: The approach to naturalized flow development in CDSS for Colorado is well documented for the entire modeling period from 1929 through 1998. Only review of the data with a possibility of minor corrections will be required. The sources and nature of the 1929 - 1970 data in the other states are not well documented. Presently, RiverWare assumes that off-stream depletions were computed in the same manor as the 1970-1993 period. Recent reports published by Reclamation (Colorado River Surplus Criteria, DEIS, July 2000) indicate that these off-stream depletions were not separately computed, but were lumped into the naturalized gain/loss for the reach in which they occurred. If this is truly the case, then available water is underestimated with the model.

Approach: The Colorado information will be reviewed and assessed for any needed changes, particularly in filling missing data. Any needed improvements will be implemented after Hydrology Committee approval. It is anticipated that the changes will be small, if any. Existing documentation for New Mexico, Arizona and Utah depletion estimates will be reviewed and the data validated and corrected, if necessary, utilizing consistent techniques for the full 1929-1993 period.

Responsible Parties: Primarily Reclamation with some assistance from a consultant.

Status: This task is approximately 16% complete. Colorado data are completed but rest of basin is incomplete.

F. Extend data sets forward through WY1999

Relationship to naturalized flow study: Optional analysis not necessary to match existing data set, but helpful for overall model maintenance, meeting the goals to periodically update the analysis period.

Need: Extension of the full data set maintains consistency with CDSS approach to maintain naturalized flows and modeling capability to within two years of current data and meets the goal of keeping the San Juan model current.

Approach: Depletion and water supply data will be updated based on existing data for the 1994-1999 period. Data will be entered into the CDSS database or interfaced through DMI's and utilized in the San Juan model, maintaining consistency of approach with the earlier period of record.

Responsible Parties: Primarily Reclamation with some assistance from a consultant.

Status: This task is approximately 15% complete. Recorded hydrology and diversions are available in usable formats but no work has been done on other data.

G. Configure CDSS for full data set and compute naturalized flows for the period of available data.

Relationship to naturalized flow study: Required as a part of the naturalized flow study. Not needed otherwise.

Need: The most cost-effective method of naturalized flow computation is to use the existing CDSS model.

Approach: Colorado or a consultant familiar with CDSS will update the CDSS database with data produced under the foregoing tasks, configure CDSS for naturalized flow calculation and operate the model to produce the monthly naturalized flows at the nodes identified in the model structure. Naturalized flows will be verified by operating the model in simulation mode with the configured depletions, comparing predicted flows against gage.

Responsible Parties: Primarily a consultant familiar with CDSS or the state of Colorado, with input from Reclamation.

Status: This task is approximately 18% complete. Configuration is complete except for main stem reconfiguration. Calibration awaits completion of task H.

H. Develop CDSS functionality in RiverWare.

Relationship to naturalized flow study: Required as a part of the naturalized flow study and model redevelopment. Not needed otherwise.

Need: To utilize CDSS generated naturalized flows, the San Juan model must replicate the methods used in CDSS.

Approach: CDSS functionality and nodal configuration will be analyzed and replicated in RiverWare. Some additional coding may be required to allow efficient replication. Return flow lagging and delivery priority are two known areas of additional functionality that must be implemented in RiverWare. Methods for handling variable irrigated area and variable efficiency depending on water supply presently included in RiverWare, may need implementation in CDSS. Upon review and approval of the Hydrology Committee, the identified functionality will be included in the appropriate model.

Responsible Parties: Primarily Reclamation with some consultant input.

Status: This task is approximately 69% complete. Engineering functionality has been implemented. Decision support (water rights) options are being tested.

I. Disaggregate monthly naturalized flows, diversions and depletions into pseudo daily values.

Relationship to naturalized flow study: Required as a part of the naturalized flow study and model redevelopment. Not needed otherwise.

Need: The flow recommendations require an estimate of timing of flows on a daily basis. The present San Juan model operates on a monthly time-step with results disaggregated into pseudo-daily values below Navajo Dam in a post processor, requiring recomputation of water balance for each run. As water development increases and the depletions depart from the historic pattern, this method becomes less accurate. Disaggregation of the naturalized flows and system demands below Navajo Dam into a pseudo-daily time step provides the most consistent method of approximating naturally shaped hydrographs necessary for the flow recommendations.

Approach: Once monthly naturalized flows are computed and calibrated, they would be disaggregated into pseudo-daily values by utilizing the gage pattern of a key-station representing reasonably naturalized flow for the same or similar drainage, adjusting values to maintain water balance and eliminate negative flows. A process would be developed and implemented for disaggregating monthly diversions and ET into pseudo-daily values. Non-irrigation demands would be computed on a psuedo- daily basis as well.

Two model implementations are possible. The first would be to continue the monthly operation, but prepare model rules that would maintain pseudo-daily accounting with the disaggregated values for each model object downstream of Navajo Dam. Upstream of Navajo Dam, the monthly time step would remain. San Juan-Chama diversions would be computed on the same pseudo-daily basis presently used in the model. The second approach would be to develop a psuedo-daily time-step model. To improve execution speed, a two-step process could be used whereby a full detail run would be completed and the tributaries not affected by operation of Navajo dam output. Then all the simulation runs could be completed utilizing the output from the detailed model for these “fixed” elements. In either case, additional calibration would be required to demonstrate agreement with gage flow. The final approach decision would be based upon an investigation of the practicality of each approach and the approval of the hydrology committee.

Having available the daily values in the model allows the Navajo Dam operating rules to have access to the data upon which the flow recommendations are based. It is likely that the operating rules will change based upon this new available data, requiring development of new rules within the San Juan model.

Responsible Parties: Reclamation and consultants.

Status: This task is 0% complete. Most work will not commence until monthly model output are available.

J. Update and calibrate the San Juan Basin RiverWare simulation model to match CDSS configuration.

Relationship to naturalized flow study: Required as a part of the naturalized flow study and model redevelopment. Not needed otherwise.

Need: Configuration to match CDSS functionality, nodal structure and results are necessary for correct utilization of CDSS naturalized flows. The present model has a number of processes that have been implemented to match USBR naturalized flows that have been the source of concern for model reviewers. Re-configuration to match naturalized flow assumptions is necessary to alleviate these concerns.

Approach: Once the functionality described in task H is completed, the RiverWare model will be configured to match CDSS on a monthly time step and calibrated to monthly gage flows. When satisfied with the results of the monthly calibration, the psuedo daily values will be introduced and again calibrated against gage flows. This second calibration step will attempt to match hydrograph shape by month, rather than target specific daily flows. In completing this calibration step, monthly mass balance will be preserved. The hydrograph shape calibration will utilize only the daily disaggregation features to avoid disrupting the monthly calibration. The final steps are to implement the reservoir operating rules designed to meet the flow recommendations, configure the model with the present baseline depletions and complete model simulations to optimize meeting system demands, including those for irrigation, municipal, industrial and fish and wildlife.

Responsible Parties: Reclamation and the consultants who assisted with the daily disaggregation.

Status: This task is approximately 3% completed. Some sensitivity testing has been identified but not yet performed. Scoping of alternatives should occur in early fall 2001. Implementation should commence in late fall 2001.

K. Coordinate development with Hydrology Committee and Interested Parties.

Relationship to naturalized flow study: Required as a part of the naturalized flow study and model redevelopment. Not needed otherwise.

Need: The quality of the model is improved as it is reviewed by an oversight group. The Hydrology Committee has been developed for that purpose. Other interested parties not presently participating on the Committee may also want review opportunity.

Approach: Reclamation and the involved consultants will prepare interim review documents and presentations to brief the interested parties on progress at key points in the development process as indicated in the tasks above and to incorporate input from the Committee. This information will be presented at regularly scheduled committee meetings.

Responsible Parties: Reclamation and consultants in relation to work completed by each.

Status: This task is approximately 30% complete. Coordination continues with Hydrology Committee and other interested parties.

L. Develop documentation.

Relationship to naturalized flow study: Required as a part of the naturalized flow study and model redevelopment. Documentation is required for any task completed.

Need: One of the key limitations in the development of the San Juan model to date has been the lack of, or difficulty in following, documentation of work performed in the past. Presently, documentation is being revised to better describe the process to date. Appropriate review and efficient long-term maintenance requires good documentation

Approach: During the completion of each task, detailed notes will be maintained and documentation of the completed task prepared. This documentation will be combined into formal model documentation, covering the basis of the naturalized flows, the construction of the model and a guide to model operation. Also, included will be a process for maintaining version control and archiving previous versions of the model and associated data relating to any key utilization of the model.

Responsible Parties: Reclamation and consultants in relation to the work accomplished.

Status: This task is approximately 21% complete. Web page has been prototyped that includes links to documentation. Development of the documentation continues for the hydrology model.

Table 1. Revised FY 2001 proposal estimated schedule, labor requirement and cost, and estimated funds to be expended in FY2001 and schedule and proposed funding for FY 2002 for completion of naturalized flow analysis and model development. (10/31/2001)

Task	FY 2001 Proposal	Professional time - staff days			FY 2001 Funds	FY 2002 Funds	Revised Estimated Total Cost	Revised Target Schedule
	Schedule	USBR	Consultant	Total				
A. Analyze and correct gage errors.	Nov-00	0	20	20	\$16,000	\$0	\$16,000	Sep-02
B. CDSS interface	Nov-00	60.5	5	65.5	\$25,092	\$14,862	\$39,954	Mar-02
C. Data systems development	Jan-01	60.5	5	65.5	\$25,092	\$14,862	\$39,954	Mar-02
D. Correct 1970 -1993 database	Mar-01	15	0	15	\$4,088	\$5,084	\$9,172	Mar-02
E. Extend data sets to 1929	Apr-01	10	0	10	\$0	\$6,540	\$6,540	Feb-02
F. Extend data sets from 1993 to 1999	May-01	10	0	10	\$0	\$6,540	\$6,540	Mar-02
G. Configure and Calibrate CDSS	Jun-01	89	8	97	\$27,330	\$37,736	\$65,066	Mar-02
H. Implement functionality in Riverware	Jun-01	26	0	26	\$16,788	\$0	\$16,788	Feb-02
I. Daily disaggregation	Aug-01	24	65	89	\$0	\$65,630	\$65,630	Jul-02
J. San Juan Model upgrade / calibration	Sep-01	76	58	134	\$0	\$97,348	\$97,348	Sep-02
K. Coordination with stakeholders	Through-out	26	10	36	\$18,939	\$26,268	\$45,207	Sep-02
L. Develop complete documentation	Nov-01	55	30	85	\$13,601	\$44,484	\$58,085	Sep-02
				Expenses	\$23,173	\$44,065	\$67,238	
				Total	\$170,103	\$363,419	\$533,522	

Expenses include travel, software, work station procurement, work station training, work station support, and Riverware modifications.

Hydrology Committee Proposal No. 2
Improve Stream Gaging and Improve Flow Measurements in the San Juan River System
Fiscal Year 2002 Project Proposal

Background:

There are five USGS streamflow gaging stations on the main stem of the San Juan river that are very important to the operation of the river and play an important role in the implementation of the flow recommendation for the recovery of the endangered fish.

During FY2001 arrangements were made with the USGS to conduct one additional trip each month to each of the four San Juan River gages in New Mexico (Archuleta, Farmington, Shiprock, and Four Corners) at a total cost of \$1,809 per month, or \$21,672 per year. The USGS started taking the additional readings around July 1, 2001. Sufficient data has not been collected yet to evaluate this program.

Also arrangements were made to move the Four Corners gage to the right bank of the river. The original cost estimate to move the gage was \$3,000. The final costs estimate by the USGS to move the gage was \$7,063. A recommendation was made by the Hydrology Committee that the gage be moved. Arrangements were made with the USGS to move the gage.

Need:

The need still exists and there is still a very important need for accurate stream gaging data on the San Juan River to insure proper implementation of the flow recommendations. .

Approach:

The Hydrology Committee is recommending that we continue having the USGS take additional flow measurements and service the gaging station at least twice as often on the four stations on the San Juan River in New Mexico. (Note: initial cost for operation of the stations is paid by another program.) As states above the cost estimate for visiting the stations one additional time per month would cost \$1,809 per month (\$21,672 per year, FY2001 cost level) The Hydrology Committee is recommending that approximately \$23,000 (increased due to probably increase by the USGS due to inflation) be budgeted to continue this program for another year.

Hydrology Committee Proposal No. 3

Additional Model Runs Fiscal Year 2002 Project Proposal

Background:

In FY 2001, \$10,000 was budgeted for the Hydrology Committee to conduct model "runs" to evaluate hydrology issues and sensitivity. No request have been made by the Coordination, Biology, or Hydrology committee and it appears that none of this funding will be needed during FY2001.

Need:

With the reconfiguration of the model being completed in FY 2002, there is a strong possibility that there will be requests by the Coordination, Biology, or Hydrology Committees for additional model runs..

Approach:

The runs would be conducted using the most current version of the model. In order to fund these model "runs" the Hydrology Committee is requesting \$10,000 for Bureau of Reclamation to perform the work. The "runs" would be only at the request of the Coordination, Biology, or Hydrology Committees.